Effect of environmental factors on the workability of castables

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Chendu 2024.10

CATALOGUE

Research Background

01

PART

Background

The high-purity system castables are increasingly used in the metallurgical Industry. The service performance of castable is crucial for safe and efficient metallurgical production.

High-purity system castables

- Corundum castables
- Corundum-MgO castables
- Corundum-spinel castables
- ……

Background

- Diversity of chemical components
- Diversity of operational environments(T)
- Compatibility with water-reducing agent

- Difference on water addition content
- Compatibility with castable high-temperature properties

- Addition of metal Al
- Compatibility with castable workability

——The performance of water-reducing agents has a significant impact on the workability and service performance of castables!

Effect of ambient temperature on castable properties

02

PART

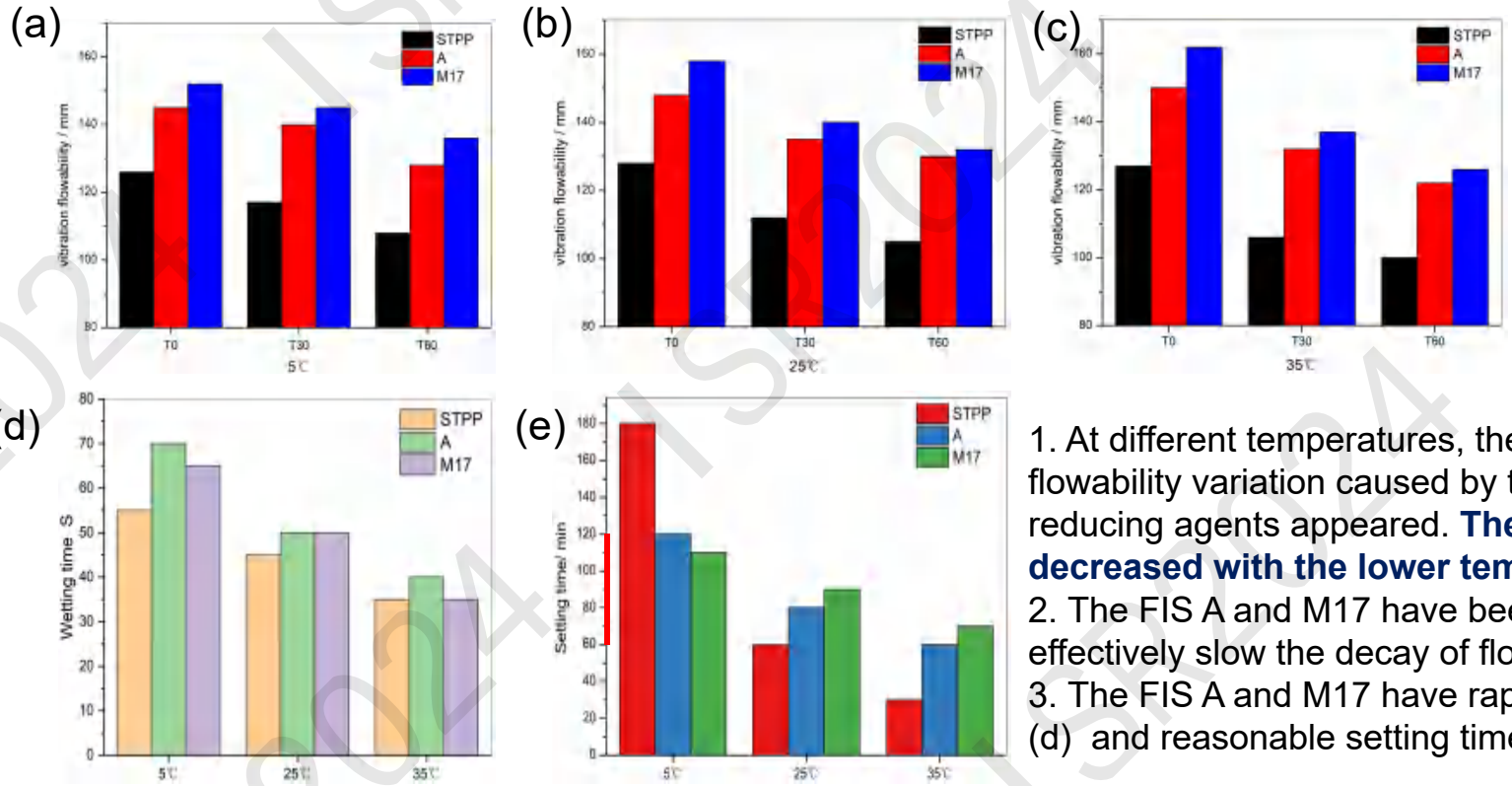
Experimental

Corundum-spinel castables		
Tabular alumina	10-0 mm	72
	200 mesh	4
$MgAl_2O_4$ spinel	200 mesh	10
70CA cement		4
α-Al_2O_3	2 μm	10
Water-reducing agent		**Variable**
Explosion-proof fiber		0.1
Water addition content		3.8

Water-reducing agent	Content %
Sodium tripolyphosphate (STPP)	0.2
Foreign integrative superplasticizer A (FIS A)	1
Monoladd M17	0.4

Results and analysis

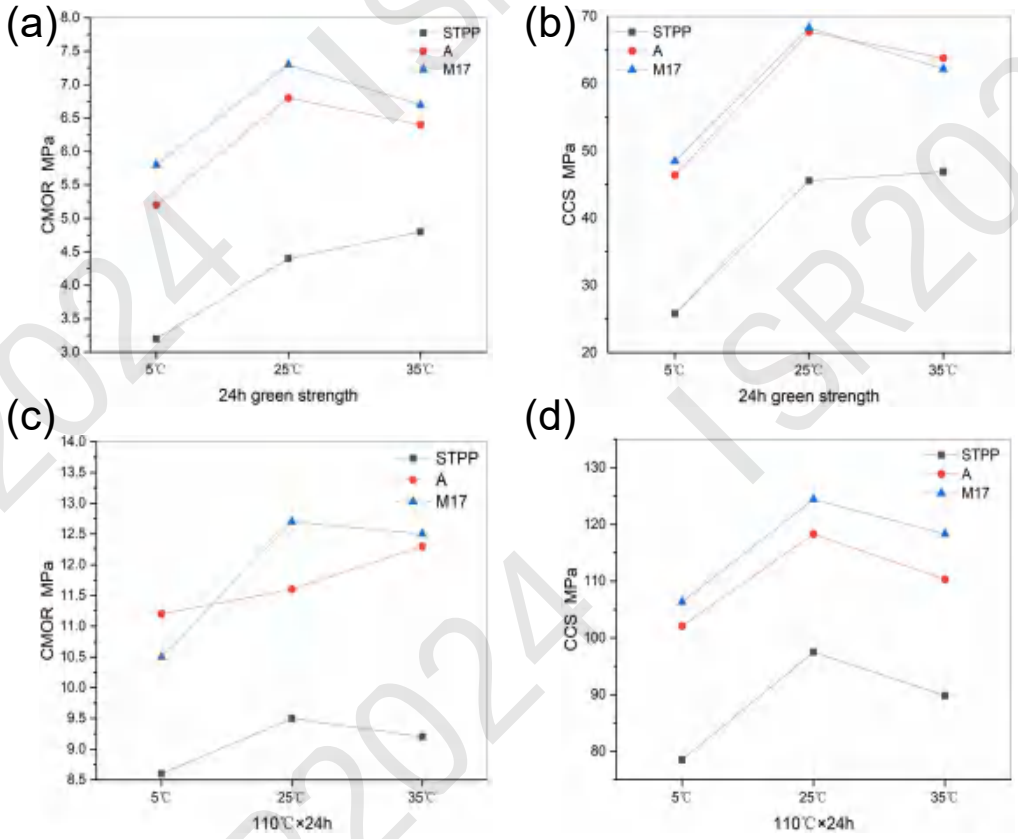
Flowability and setting time at different temperatures



1. At different temperatures, the notable flowability variation caused by the water-reducing agents appeared. **The flowability decreased with the lower temperature (a~c).**
2. The FIS A and M17 have been shown to effectively slow the decay of flowability **(a~c).**
3. The FIS A and M17 have rapid wetting time (d) and reasonable setting time (e).

Results and analysis

Mechanical strength at different temperatures



- The low demolding strength at the lower temperature can be improved using the integrative superplasticizer (M17, a and b).
- The mechanical strength of castables after drying at 110 ℃ was closely related to the flowability. The close packing led to the higher drying strength.(c and d)

Summary:

1. At different temperatures, the notable flowability variation caused by the water-reducing agents appeared. The flowability decreased with the temperature.

2. The reaction rate of water-reducing agents was affected by the temperature, which decreased with the fall of temperature. While the wetting time can be increased by the superplasticizer M17.

3.For castables prepared at different temperatures, the reasonable setting time and high strength in early period can be realized by using the integrative superplasticizer (M17).

Effect of water addition on castable properties

03

PART

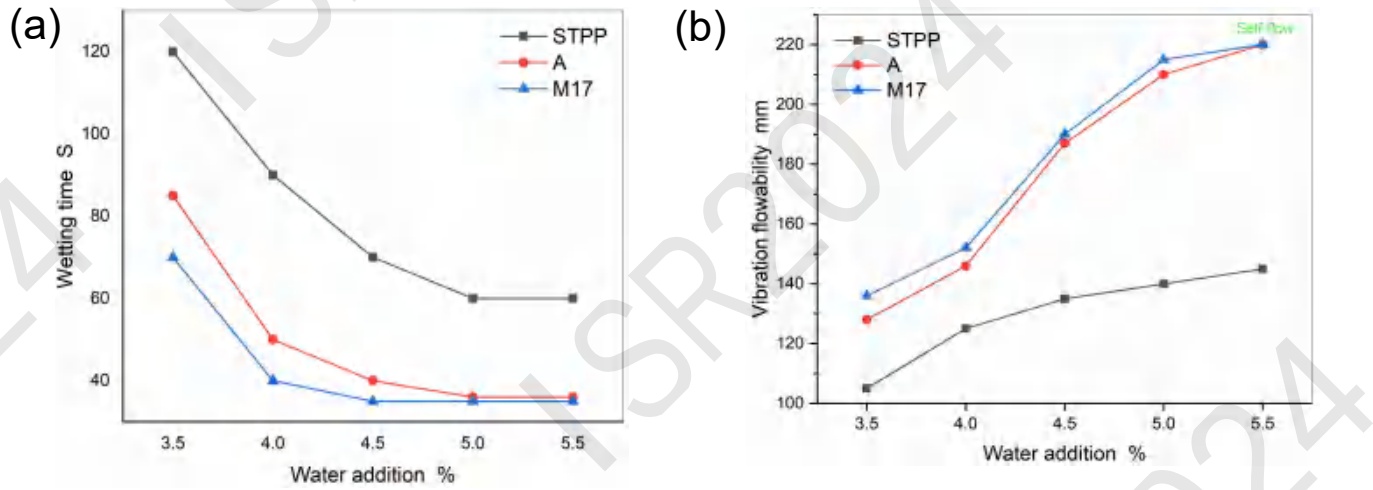
Experimental

Corundum castables		
Tabular alumina	10-0 mm	72
	200 mesh	13
70CA cement		5
α-Al_2O_3	2 μm	10
Explosion-proof fiber		0.1
Water-reducing agent P201		0.1
Water-reducing agent		**Variable**
Water addition content		**3.5-5.5%**

Water-reducing agent	Content %
Sodium tripolyphosphate (STPP)	0.2
Foreign integrative superplasticizer A (FIS A)	1
Monoladd M17	0.4

Results and analysis

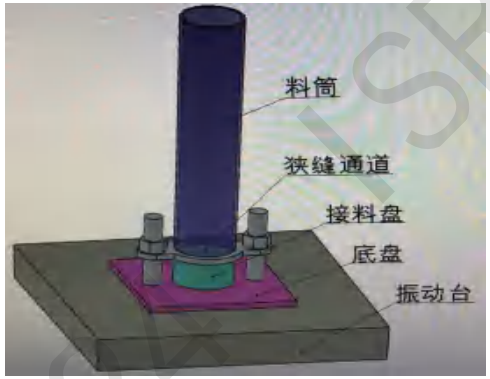
Flowability and wetting time with different water addition



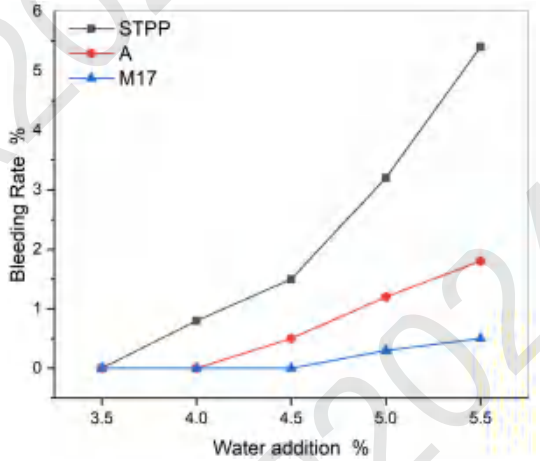
- Under lower water addition, the wetting time was longer and the flowability decreased.
- With water addition content rising, the wetting speed increased and the flowability could be improved significantly.
- M17 has the lowest weeting time, and highest flowability.

Results and analysis

Bleeding ratio test with different water addition



Device for castable bleeding ratio test



Test principle: The bleeding ratio is calculated based on measuring the slurry mass in the receiving tray which released from the castables through the narrow channel when vibrating.

Specific methods are as follows:

(1)Record the mass of cylinder and receiving tray as M1 and M2, respectively.

(2) Measure the mass of castables in the cylinder (M3).

(3) Fix the cylinder, receiving tray, and chassis on the vibration table, and vibrate for 10 minutes.

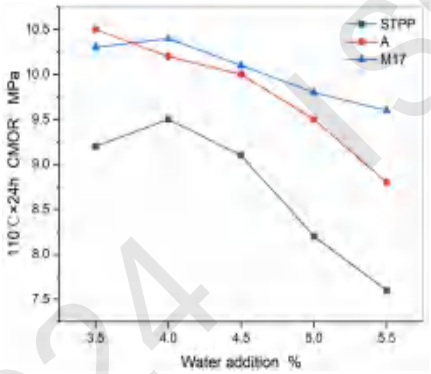
(4) After vibrating, measure the total mass of receiving tray and slurry (M4), then the bleeding ratio (B) can be calculated as follows:

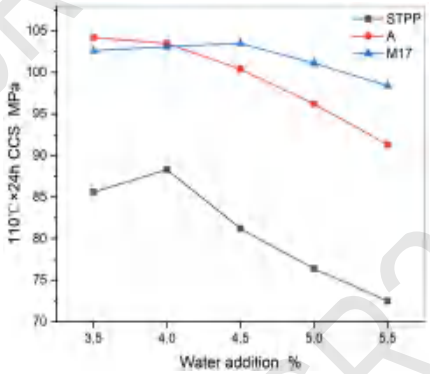
$$B = (M4-M2) * 100\% / (M3-M1)$$

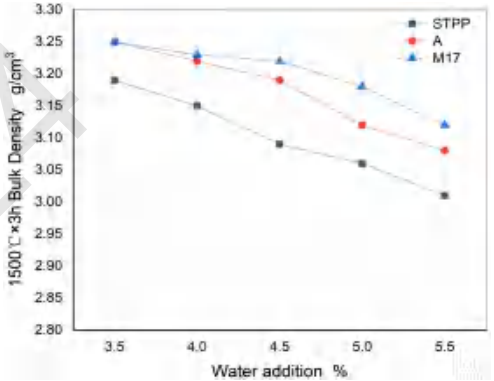
- The bleeding in castables can reduce it's long-term strength and bulk density .
- With high water addition, castables containing STPP showed the highest bleeding ratio, the next was FIS A. M17 exhibited the best **anti-bleeding property**.

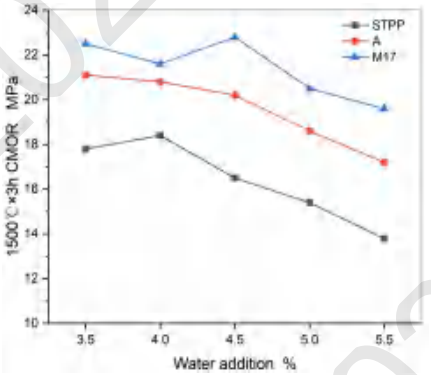
Results and analysis

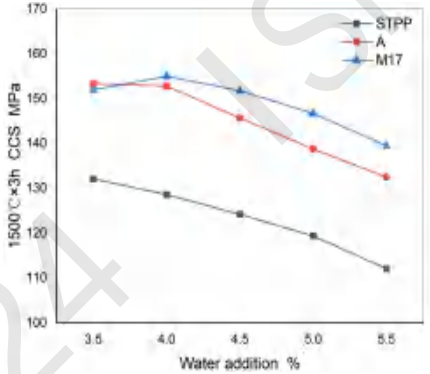
Physical properties with water addition











The excessive water addition resulted in the layered bleeding in castables, reducing the long-term strength and bulk density.

The sample containing M17 displays the best mechanical properties when subjected to the same degree of water addition.

Summary:

1. Different water addition content resulted in the obvious variation of castable wetting time. Under the lower water addition content, the wetting speed was smaller, which affected the flowability. However, the added superplasticizer (M17) could effectively increase the wetting time and improve the flowability.

2. The excessive water addition resulted in the layered bleeding in castables, reducing the long-term strength and bulk density, which could be effectively avoided by the addition of superplasticizer M17.

Effect of metal Al powders on castable properties

04

PART

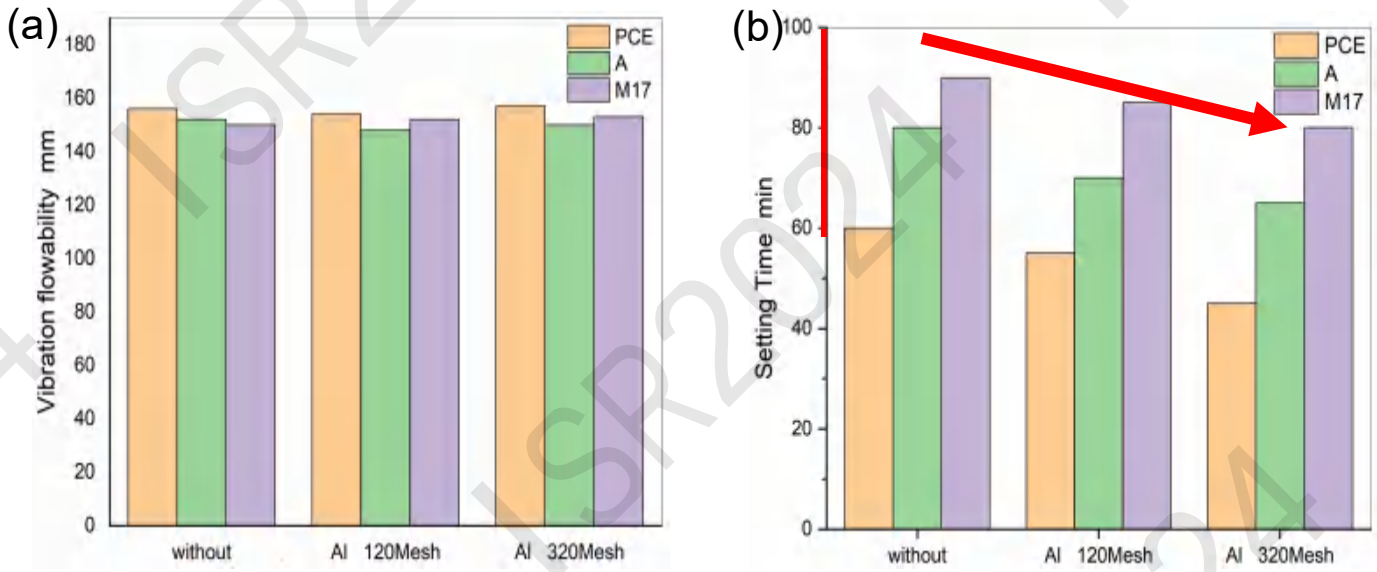
Experimental

Corundum-MgO castables

Tabular alumina	10-0 mm	72
	200 mesh	12
97 fused magnesia	180 mesh	4.5
70CA cement		5
α-Al_2O_3	2 μm	10
Microsilica		0.5
Explosion-proof fiber		0.1
Water-reducing agent		**Variable**
Water addition		4.0
Metal Al		0.02

Water-reducing agent	Particle size of Al
Polycarboxylate Ether（**PCE**）（0.1%）	120 mesh
	320 mesh
A（1%）	120 mesh
	320 mesh
Monoladd **M17**（0.4%）	120 mesh
	320 mesh

Flowability and wetting time under different Al powders

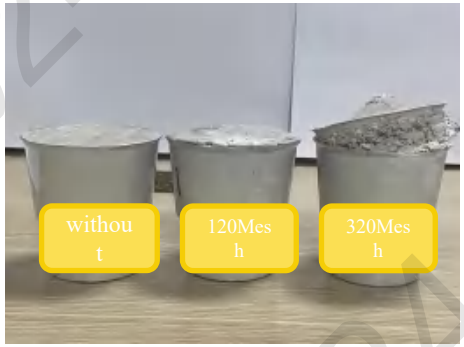


- The addition of Al powders did not affect the flowability of castables, however, influenced the setting time: the solidification speed of castables increased with the decreasing of Al powders particle size.

Swelling observation of castables

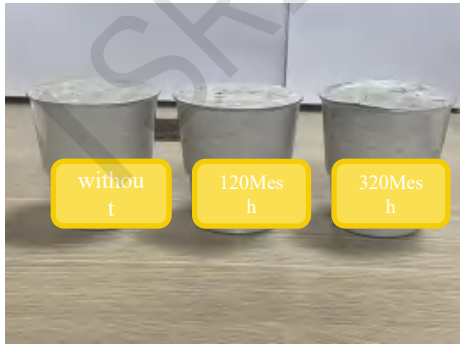
	PCE	A	M17
without	No	No	No
Al 120Mesh	Swelling	No	No
Al 320Mesh	Serious swelling	Slight swelling	No

(a)



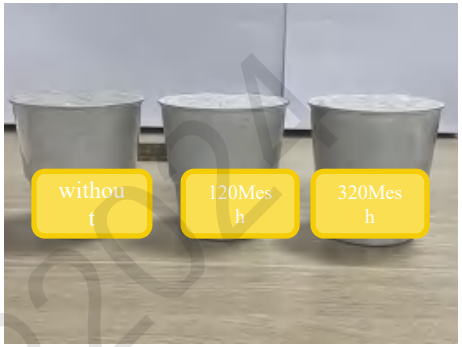
PCE

(b)



A

(c)



M17

Summary:

1. The addition of Al powders did not affect the flowability of castables, however, obviously influenced the setting time.

2. The compatibility between the particle size of Al powders and the water-reducing agent was found to play an important role in the properties of castables. In cases where there was poor compatibility, the castables exhibited swelling and cracking. **PCE** was found to be unsuitable for use when added to castables, while water-reducing agent **A** could only be used when small particle-size Al powders were added. However, superplasticiser **M17** was found to be compatible with all types of Al powders.

Conclusions 05

PART

Conclusions:

This work studies the effect of ambient temperature on properties of corundum-spinel castables, the effect of water addition on properties of corundum castables and the effect of metal Al powders on properties of corundum-MgO castables. The main conclusions as follows:

(1) The ambient temperature could influence the reactive activity of water-reducing agent, which then affected the wetting time and flowability. Meanwhile, the temperature also influence the solidification time. These problems can be effectively solved by the addition of superplasticizer M17.

(2) Different water addition content resulted in the obvious variation of castable wetting time and the layered bleeding. Superplasticizer M17 has a good effect on reducing the layered bleeding under high water addition.

(3) The compatibility between the particle size of Al powders and water-reducing agent played a important role in the properties. The poor compatibility will result in the swelling and cracking of castables.

Thanks